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A *Perspectivalist* Better Best System Account of Lawhood

Michela Massimi

1. Introduction

Two questions have catalyzed the debate surrounding laws of nature. Do laws govern nature? And what is the fundamental ontology of nature that is compatible with laws and their (governing or not) role? David Lewis has laid down an influential approach to these two questions. On Lewis's account, laws do not govern nature because nomic facts reduce to non-nomic facts about natural properties. Humean Supervenience (a tenet of Lewis' account) maintains that modal facts supervene on this mosaic of non-modal facts about sparse natural properties. Lewis' Humean ontology is modest: it consists of a (physics-driven) vocabulary of sparse natural properties (e.g. mass, charge, spin, among others) distributed over spacetime. Humean ontology is a mosaic of pixelated natural properties, whose constant co-occurrence defines all there is.

Thus, an electron is a well-defined cell in the Humean mosaic of co-occurrent natural properties (negative electric charge, half-integral spin, mass of 0.511 MeV/c^2). Interestingly, some of these natural properties co-occur in more than one well-defined cell of the mosaic. For example, half-integral spin co-occurs with the property of negative electric charge (in the cell of properties defining the kind *electron*). But it also co-occurs with the property positive electric charge (in the cell of properties defining the kind *positron*). That is what makes Humean ontology a Legoland of possible reconfigurations of the same fundamental natural bricks (with no underlying causal glue), upon which natural kinds are mapped.

Nomic facts about natural kinds are then said to supervene on this Legoland of natural properties. Pauli's principle or Coloumb's law equally supervene on non-nomic facts about the electron's natural properties (e.g. the half-integral spin going hand-in-hand with antisymmetric states; the negative electric charge going hand-in-hand with repulsion of similarly negative electric charges, without any causal glue underpinning their going hand-to-hand). Lewis' Best System Account of lawhood[1] finds its ultimate justification in this neat ontological scenario: how nomic facts supervene on non-nomic facts about natural properties. For it contends that laws (do not govern) but simply are regularities; and for a regularity to be a law, it ought to fit with other laws in a system that achieves the best balance of simplicity and strength (the latter understood as information content). There are regular, co-occurrent, non-nomic properties

[1] See Lewis (1973), pp. 73-74.

about the electron's spin, its electric charge and a bunch of other natural properties that undergird Pauli's principle and Coloumb's law (among many others), and make them part of a best system. But no similar regular co-occurrence of properties is found to undergird, say, "All fruits in Smith's garden are apples". The latter is not part of any best system.

The goal of this paper is to defend a suitably modified BSA account of laws, which is still kosher to the Humean spirit of Lewis' proposal, but does not fall prey to some classical objections to Lewis. The modified version of BSA that I am going to propose deals in particular with the problems of subjectivity and nomic necessity that Lewis' BSA typically faces. Under the modified BSA account suggested in this paper, it is not the Humean mosaic of sparse natural properties *alone* that ultimately grounds laws of nature. But it is the Humean mosaic *together with* our standards of simplicity, strength, and balance that ground laws of nature. More to the point, I am going to argue that our standards of simplicity, strength, and balance change over time and are perspectival, in some relevant sense here to be clarified. I will be arguing that simplicity, strength and balance are not standards pertaining to some non-better specified God's eye-view (or what Ned Hall has aptly called Lewis's LOPP, Limited Oracular Perfect Physicist)[2]. Rather, they are perspectival standards adopted by real scientific communities across the history of science.

Thus, my objective is to unpack some unexpected resources available to a Lewisian account of lawhood (when dealing with classical objections about subjectivity and nomic necessity), at the condition of rethinking the Lewisian tenet that the standards defining the best system belong to some ideal LOPP. As a consequence of this move, for a regularity to be a law, it has to feature within a perspectival series of Best Systems, defined by our historically evolving standards of simplicity, strength, and balance. Thus, the main point of my paper is simply to reject the Lewisian idea that standards defining the Best System are fixed once and for all, as opposed to belonging to real historical communities that have *interpreted those very same standards* in very different ways across time. This is good news for Lewis's view. Far from shaking the foundations of Lewis' Best System, my perspectival move proves in the end serendipitous to re-assessing the resilience of Humean regularities that we count as *bona fide* laws across the history of science and theory-change.

My start-up problem is the maybe unsurprising observation that our standards of simplicity, strength, and balance seem to have evolved remarkably across the history of science. As a result, there seems to be more than one Best System featuring some important regularities that are non-controversially regarded as fundamental laws. Let us consider two paradigmatic

[2] See Hall (2015).

examples from physics: the law of conservation of mass and the law of conservation of momentum. Mass is a natural property of fundamental particles *par excellence*. All fundamental particles can be classified on the basis of their identifying masses. New particles are discovered by identifying unexpected mass values against a background of known events (e.g. the 125 GeV of the Higgs boson; or the 3.1 GeV bump for the *J/psi* particle). What better candidate for a Lewisian natural property acting as the basis on which laws of nature (indeed, fundamental ones such as conservation of mass) supervene? Under the Lewisian story, one ought to say that conservation of mass (together with momentum conservation, and others) form a best system of nomic facts that maximizes simplicity in premises and strength (or information content) in the conclusions (where simplicity and strength are taken as fixed standards belonging to a LOPP). In other words, it is the existence of mass as a natural property of fundamental particles, and its co-occurrence in a Humean mosaic of non-nomic facts about other natural properties that underpin the law of conservation of mass (as well as other laws of nature) in our best system.

Leaving here aside van Fraassen's objection against what Lewis' "eschatology of science",[3] let us ask a slightly different (albeit related) question. Assuming for the sake of Lewis' argument that scientists do try to achieve the best balance between simplicity and strength as their knowledge of the natural world increases, *how many* Best Systems have there been in the history of science where conservation of mass has featured as a "law" (and, indeed, a fundamental one)? How do the Lewisian standards of simplicity and strength have to be understood in these different Best Systems? (I am going to ask similar questions about conservation of momentum shortly thereafter).

Let us start with conservation of mass and let us go back to Antoine Lavoisier, who is usually credited for having discovered it. He certainly was not concerned with producing a Best System of axiomatised knowledge, from which conservation of mass could follow. If anything, Lavoisier's gravimetrics and his use of the balance for establishing the principle of conservation of weight (note: *weight*, not mass) has been rightly associated with his double career as a tax collector, given that at the time the balance was the instrument of assayers and apothecaries, more than physicists or chemists.[4] More to the point, even granted that Lavoisier's principle of conservation of weight might have featured somehow in a Lewisian Best System combining simplicity and strength, how did Lavoisier and his contemporaries understand simplicity?

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[3] B. van Fraassen (1989), ch. 3.
[4] See B. Bensaude-Vincent (1992).

Simplicity and strength are notoriously vague notions. But when it comes to chemistry, it might be tempting to think of Lavoisier's system of chemistry as being simple in the classification of chemical substances and in the treatment of chemical compounds. The simplicity of Lavoisier's system can be understood as the outcome of applying gravimetrics methods to chemical compounds (e.g. weighing in and out every substance involved in chemical reactions) so that it was possible to reach conclusions about both the mosaic of non-nomic facts (e.g. that oxygen is a separate substance) and nomic claims supervenient on them (e.g. that metallic calxes weighted as the original metal plus the oxygen involved in calcination).

Stahl's chemistry at the time formed a different system, with different non-nomic facts (oxygen was not in the mosaic, but phlogiston was) and, as a result, different nomic claims too (about calcination and combustion). Its simplicity was not defined by the application of gravimetric methods to chemical compounds but by analogies and chemical prototypes.[5] Was Lavoisier's system better than Stahl's? Hard to say. In a way, yes, as reliably identifiable regularities (thanks to gravimetric methods) are simpler than regularities identifiable via mere analogies and intuitions about what might count as a prototype in chemistry. In another sense, no, because when it comes to strength Lavoisier's system allowed in non-nomic facts about caloric, as much as Stahl's system slipped in non-nomic facts about phlogiston. Thus, Lavoisier' system of chemistry, while regarded the best at its own time, did not exactly achieve the Lewisian LOPP-ian optimal balance of simplicity in the premises (given caloric still featured in it) and strength in the conclusion (given that caloric-related phenomena were meant to derive from it).[6] In the age of Enlightenment, the regularity called "the law of conservation of mass" was downstream of Lavoisier's standards of simplicity and strength.

But, historically, there have been other Lewisian Best Systems featuring mass conservation as a fundamental law. After all, it was the great success of Newtonian mechanics that placed mass centre stage as an intrinsic natural property—key to an entire branch called point mechanics. For in Newtonian mechanics, any body can be thought of as a mass point with mass **m**, position along Euclidean coordinates *x, y, z,* and velocity $\vec{v}$ (along the Euclidean coordinates). By combining mass and velocity, a new physical quantity can be obtained, *momentum*, and momentum is itself a conserved quantity —what was known to the Cartesians of the early eighteenth century as *dead force* ($\mathbf{m}\boldsymbol{v}$), as opposed to Leibniz's *living force* ½ $\mathbf{m}v^2$, which would later become known as kinetic energy and feature in the law of conservation of energy

[5] For the importance of gravimetrics methods in Lavoisier vis-à-vis Stahl, see J. B. Gough (1988), pp. 17-20.

[6] "These discoveries give reason to hope that chemistry may one day arrive at the most beautiful state of simplicity. It is perhaps no improbable conjecture that all the bodies in nature may be referred to one class of simple combustible elementary substances, to oxygen and to caloric; and that from the various combinations of these with each other, all the variety produced by nature and art may arise" Lavoisier (1799), p. 224.

$$\tfrac{1}{2}\,\mathbf{m}v^2 - \int_0^x F(x)dx = const$$

(where the first term is what we now call kinetic energy and the second term is potential energy). It was one of the greatest achievements of classical mechanics that conservation of energy so defined could be deduced by integration from Newton's second law of motion whenever the force function F is known. Moreover, it was one of the great mathematical achievements of the eighteenth century to show how from Newton's laws it is also possible to derive D'Alembert's principle and Lagrange equations.

What would count as simplicity and strength in the Newtonian Best System where mass conservation (and momentum conservation) feature? Roger Cotes, in the Preface to the second edition of the *Principia*, paradigmatically explained the kind of simplicity at work in the Newtonian system.[7] Newton himself clarified what he meant by simplicity in his first rule of reasoning: i.e. "no more causes of natural things should be admitted than are both true and sufficient to explain their phenomena".[8] We have long abandoned this Newtonian way of interpreting simplicity as identifying true and sufficient physical causes for given phenomena. For example, Cartan's geometrized gravitation theory no longer interprets gravitational force as a physical "cause" for planetary motion because it endorses a variably curved inertial structure to define freely falling trajectories for bodies (similar to general relativity). And it has even been argued that simplicity should be understood along the lines of geometrized Newtonian gravitation with its curved spacetime as the best, natural setting for Newton's gravity (a setting that Newton himself would have preferred, had he known the mathematics for it).[9]

More to the point, already in the early nineteenth century, Hamilton came up with an alternative way of systematizing motions of mass point bodies, which instead of force laws,

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[7] "Those who fetch from hypotheses the foundations on which they build their speculations, may form indeed an ingenious romance, but a romance it will still be. There is left then the third class, which professes experimental philosophy. These indeed derive the causes of all things from the most simple principles possible; but then they assume nothing as a principle that is not proved by phenomena. They frame no hypotheses" R. Cotes' Preface to the Second Edition of Newton's *Principia*. In Newton (1687/1713).

[8] For example, we no longer take Newton's gravitational force as a *vera causa* —"true cause"— of the phenomena it was intended to explain (qua action at a distance between point-masses). Instead, we understand gravitational force in terms of mass-energy tensor in relativity theory, causing planets to orbits around the Sun by warping spacetime. To echo Cohen and Callender, our kind 'gravitational force' has changed since Newton, and with it, inevitably, our understanding of the simplicity of Newton's system and its laws has changed too. Moreover, we know that to explain planetary motion, a lot more assumptions are necessary than just positing Newton's law of gravity.

[9] Recently, Eleanor Knox (2014) has indeed argued for the superiority of Newton-Cartan geometrized gravitation over the orthodox Newtonian gravitation as capturing "the best spacetime setting for Newtonian gravitation, judged by its own light. In fact, the move to a curved spacetime setting for NG [Newtonian gravitation] is motivated by much the same reasoning that usually impels us to insist that Neo-Newtonian spacetime, and not Newton's absolute space, is the best setting for Newtonian gravity" (ibid., p. 864).

starts with a Lagrangian function featuring in what became known as Hamilton's principle. And Hamilton's principle redefined simplicity not in terms of deriving the "causes of things from the most simple principles" (i.e. force laws); but in terms of integrating the Lagrangian function of the variables of state over all the possible paths a mass point might take, and choose the one with the smallest value. So here we have yet another example of the standard of simplicity has been subject to different interpretations across the history of science.

Hamilton's principle can be extended to quantum mechanics. And when it comes to quantum mechanics itself, and to the so-called fine-structure Hamiltonian defining the state of a quantum mechanical system, mass is no longer a fixed and immutable natural property, because it is subject to the relativistic correction of the rest-mass energy ($m_e c^2$). Turning to Einstein's famous equation ($E = mc^2$), as Marc Lange has persuasively argued, the equation itself does not tell us the "rate of exchange" between mass and energy. Einstein's equation in fact relates a body's rest mass (which is frame-independent, or Lorentz invariant) with the body's energy (which, on the contrary, depends on speed and hence on the inertial frame; i.e. it is *not* Lorentz invariant).[10] Hence, it would be odd to conclude from these brief historical remarks that the Lewisian standards of simplicity, strength and balance are fixed once and for all, and that belong to some Limited Oracular Perfect Physicist. Instead, they are standards that have been interpreted differently across the history of science, from Lavoisier's Best System to Einstein's Best System, where mass conservation has equally featured as a fundamental law of nature. And the challenge for the Lewisian BSA is then to preserve its account of lawhood despite these perspectival changes in the standards of simplicity, strength, and balance.

Momentum conservation too (another jigsaw piece in any Lewisian Best System of nomic facts) appears to have featured across several Best Systems. It still features in contemporary ongoing searches at the Large Hadron Collider, where it is the large missing transverse momentum imbalance $\vec{p}_T^{\,\mathrm{miss}}$ in multi-jets events that physicists take as the sign of possible new Beyond Standard Model particles (e.g. supersymmetric particles, including the neutralino as a candidate for dark matter). But it would be odd to say that the Best System where the law of momentum conservation features today in Beyond Standard Model searches is one and the same Best System where it originally featured as Descartes' law of momentum conservation (used to describe elastic collisions between rigid bodies). For once, the strength (information content) of the Lewisian Best System where Descartes' law of momentum conservation (*dead force*) featured did not extend to encompass, envisage, or even dream about deep inelastic scattering of fundamental particles and hadronization due to proton-proton

[10] M. Lange (2001).

collisions at LHC, among many others. So, while perhaps one might argue that the simplicity afforded by the Cartesian Best System (where momentum conservation featured) is not that much different from possibly similar simplicity considerations in current high-energy physics Best System (via, for example, simplified models for particles' masses and cross-sections),[11] the Lewisian standard of strength is undoubtedly very different in the two cases to reflect the richer informational state of contemporary particle physics.

These brief historical remarks should suffice first to show that across the history of science there have been *more than one* Best System where both mass conservation and momentum conservation have featured as "laws" (and, indeed, fundamental ones). And, second, that these different Best Systems resort to different interpretations of the (Lewisian) standards of simplicity and strength. For a glance at the history of the physical sciences soon reveals cracks and discontinuities, shaky foundations (from Lavoisier's gravimetrics to Einstein's equation), and rival views of simplicity (Newton vs Cartan vs Hamilton) and strength (Descartes' elastic collisions between rigid bodies vs LHC deep inelastic proton-proton scattering) even in our most promising candidates for the Lewisian title of Best System. What has gone wrong with these examples?

Two main lessons emerge, in my view, from these remarks. First, any Best System account of lawhood that intends to explain nomic facts about mass and momentum (across different Best Systems in which they have historically featured) owes us an account of lawhood in terms of evolving standards of simplicity and strength. Second, something ought to be said about the changing standards of simplicity and strength that are meant to define the Best System. David Lewis famously dreaded the suggestion that standards might be dependent on us in any genuine sense. He strived to shelter his account of lawhood from what he described as the lunacy of the ratbag idealist.[12] The lunatic idealist would claim that laws change by changing our ways of thinking about them, or our ways of thinking about what counts as the best system. Lewis acknowledged that in some ways the standards of simplicity and strength are a psychological matter. But he mitigated the possible menace coming from considerations of this kind, with the view that "if nature is kind to us", the Best System will be robustly so. The robustly Best System will come out far ahead of its rivals, no matter what standards of simplicity, strength, and balance might be in place (Lewis, ibid.).

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11 Simplified models are increasingly used in contemporary high energy physics as a useful interface between theoretical physicists and experimentalists. They are neither models of the data nor theoretical models and are simplified in that they focus on only a few simple kinematic parameters such as particles' masses and their decay products in collisions.

12 D. Lewis (1994), p. 479.

But one does not need to go as far as envisaging a lunatic idealist (after all, there are not many of them around these days). A brief look at the history of science suffices to show how Lewis' account is vulnerable to the charge of subjectivity. Ned Hall has recently invited BSA-supporters to offer "a version of reductionism that gets much more serious than Lewis ever did both about what, *precisely,* the standards are for judging candidate systems, and about why – given the reductionist's metaphysical commitments – those *ought* to be the standards….In addition, the debate needs a shift in methodological priorities that places much less emphasis on intuitions about hypothetical cases, and much more emphasis on attending to the distinctive sort of work that a concept of 'law of nature' performs in actual scientific practice".[13]

In what follow, I take on board Hall's invitation to change methodological priorities and place more emphasis on the role of laws in actual scientific practice. Hence, I take some preliminary steps towards amending Humeanism about laws so as to reflect the historical evolution that our beloved laws of nature are subject to. I ultimately defend a *perspectivalist* version of the Best System Account, which builds upon (and hopefully improves on) two somehow similar moves already made in the literature by Cohen / Callender, and Halpin, respectively. My perspectivalist version of BSA is motivated by three main problems affecting Lewis' view:

(1) *Subjectivity.* Both in the original formulation (Lewis 1973) and in subsequent analyses, Lewis often referred to simplicity and strength as "partly a matter of psychology" (Lewis 1994, p. 479). An improved version of BSA should avoid subjectivity so understood while at the same time explaining Lewis' original intuition that standards are *to some extent* dependent on us (although not necessarily on our psychological make-up).

(2) *Realism.* Humeanism about laws implies realism about sparse natural properties composing the Humean mosaic of non-modal facts. But since to be a law is to feature as an axiom or a theorem in the best system; and since as the remarks above suggest, there is more than one Best System historically for the same law, how can we be realist about laws that feature across different Best Systems?

(3) *Nomic necessity.* A pressing complaint against Lewis' BSA is its inability to deliver on nomic necessity. Can an amended version of BSA improve on the score of nomic necessity? Obviously, by nomic necessity here I mean some suitable notion of nomic

[13] N. Hall (2015), p. 275.

necessity, which does not beg the question appealing to anti-Humean dispositional essential properties or necessitation relations among categorical properties.

In Section 2, I present two possible answers to these three problems. These answers have recently been proposed with an eye to improving on Lewis' BSA. In both cases, Lewis' ontology of natural properties is retained, but Humean Supervenience rejected. The first answer is in terms of a *relativized* Best System Account. The second stresses the importance of a *perspectivalist* Best System Account. I review their common ground and their points of divergence in Section 2. In Section 3, I present my own perspectivalist take on BSA. I clarify how it differs from the two other accounts discussed in Section 2, and most importantly, I illustrate how it can tackle the three aforementioned problems of subjectivity, realism, and nomic necessity.

2. *Relativized* BSA or *Perspectivalist* BSA?

Two friendly amendments to Lewis' BSA have been recently offered in the recent literature. The first one, by Cohen and Callender, proposed to *relativise* BSA. The second, by Halpin, gives BSA a *perspectivalist* twist. I briefly review both in this Section with an eye to assessing their respective success in answering the three aforementioned outstanding issues of subjectivity, realism and nomic necessity.

The main motivation behind Cohen and Callender's (2009) *relativized* BSA is to avoid what they call the problem with inter-system comparison of strength, simplicity, and balance. Namely, to assess the best system among many available ones, we ought to be able to compare their respective standards of simplicity, strength and balance. Yet, BSA involves immanent notions of simplicity, strength and balance. Thus, systems, whose basic predicates and natural kinds terms ultimately differ, cannot be compared or evaluated on the basis of how they score on simplicity, strength and balance. An additional motivation for Cohen and Callender's *relativized* BSA is to allow for laws in the special sciences (I will not pursue this second motivation here, although it has been widely discussed in the literature).[14] The problem of inter-system comparison does not just concern Goodmanian scenarios where "grue" and "bleen" might happen to be the simple natural predicates. It is instead a compelling problem arising from scientific practice. For a quick glance at the history of science soon reveals a plethora of ways of carving nature at its joints with profound consequences for what counts as a law of nature.[15] Hence, the need for a

[14] See Backmann and Reutlinger (2014) and Schrenk (2014).

[15] "Our own scientists have axiomatised phenomenological thermodynamics in a variety of ways, some using (e.g.) heat as a category and others not. The laws in each system can differ as a result. Is one axiomatization right and the other wrong because heat is or is not in that distinguished set?...Sticking with the thermodynamics example, consider the macrovariable temperature and its changing meanings and extensions. Originally identified with felt

relativized Best System Account (or *relativized* Mill-Ramsey-Lewis, MRL as they call it), which makes lawhood "relative to a choice among equally available alternatives" (Cohen and Callender 2009, p. 20). Even if the standards of simplicity, strength, and balance are vague and very sensitive to the particular choice of predicates and kinds at work in any given system, it is still possible to assess, identify, and choose the best system relative a specific choice of predicates and kinds.

This move has significant implications for assessing the classical objection of subjectivity leveled against Lewis. For under Cohen and Callender's *relativized* BSA, it is not the content of any law that is at risk of subjectivity; but instead its status as law. For example, Newton's law of universal gravitation is relative to a given choice of predicates and kinds in classical mechanics (e.g. thinking of bodies as point-sized masses; gravitational force as an action at a distance force; and so on). Yet, the behavior of bodies described by Newton's law is in no way subjective. Relativised BSA eschews subjectivity also at another level. For laws do not depend for their existence on human subjects. There can be laws (relative to a given choice of kinds *K*) in worlds without human beings insofar as they feature in the immanently Best System for that world relative to *K* (see ibid., p. 28). In other words, if there were an immanently Best System in world *w* relative to *K* (even in the absence of any actual human beings axiomating knowledge according to kinds *K*), there would be laws in *w* (relative to *K*).

Relativised BSA acknowledges that there is no Nagelian "view from nowhere" when it comes to lawhood, and it offers "a picture of laws that is essentially perspectival" without the perspectives in question being themselves subject-dependent (ibid., p. 28). This view improves on Lewis' BSA also on the score of realism. For it chimes with a variety of more modest realist views, ranging from Kitcher's 'modest realism', to Dupré's 'promiscuous realism', to Putnam's 'internal realism' (ibid., p. 20). As soon as we recognize that there are many possible ways of carving the world at its joints, relative to the research interests of given communities at given times, our realist commitments too ought to be re-calibrated to allow for a pluralism of kinds and ensuing relativity of lawhood. The Humean mosaic of sparse natural properties has to make room for a bewildering variety of kinds. Relativised kinds (rather than God's-eye-like natural properties) become the minimal ontological unit for our realist commitments, according to the

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hotness, it then was identified with empirical temperature, absolute temperature, and now statistical mechanical temperature. In each case a change in carving accompanied a change in laws. What macrovariables we choose to systematize with appears remarkably pliable. Some, like entropy, the Gibbs free energy, and more, are even somewhat gruesome" Cohen and Callender (2009), p. 17.

defender of relativized BSA.[16] Unsurprisingly maybe, given the Kuhnian flavor of the position, nomic necessity remains an open problem and an ongoing concern for the defender of relativized BSA. So any friendly amendment to Lewis' BSA ought to improve on relativized BSA on the score of nomic necessity.

The aforementioned reference to the perspectival nature of the laws emerging from Cohen and Callender's account is not casual. For both authors acknowledge their debt to a similar perspectival amendment to Lewis's view offered by Halpin (2003), to whom I turn next. Despite significant analogies between Cohen–Callender relativized BSA and Halpin's perspectivalist BSA, there are also significant differences in the way in which perspective-dependence is understood, which in turn bears on important issues such as nomic necessity for example.

Like Cohen and Callender, John Halpin's (2003) "perspectival best system account" (PBSA) too takes as its starting point the situated and contextual nature of the standards defining the Best System. Knowing the laws of nature is to comprehend a best system "*with respect to the context of our own conceptual lights*" (Halpin 2003, 142). But while Cohen and Callender understand contextuality in terms of relativizing the Best System Account, Halpin analyses contextuality in perspectivalist terms. Perspectival BSA tells us that a best system is very much a matter of perspective. But it is important to get clear about what "perspective" means in Halpin's use of the word. Perspective is not here understood along the lines of Ron Giere's (2006) "scientific perspectives" as hierarchies of models (from data models to theoretical models), which fit data. Instead, Halpin uses the term "perspective" to denote an idealized continuation of current scientific practice, which would deliver the best system as an aim of science.[17] More to the point, to be a law under PBSA is not only to describe the occurrence of regular patterns of natural properties; but it is also a matter of an observer occupying a certain perspective on the Humean mosaic. This feature implies a degree of "indeterminateness" in that laws can only be defined when a "complete perspective, i.e. an idealized continuation of actual scientific culture" is specified.[18]

[16] "The relativized MRLer, in other words, must be a kind of Carnapian or Kuhnian with respect to theory change, explaining the change from one theory to another as always the result of explanatory/pragmatic needs and not rational compulsion" Cohen and Callender (2009), p. 29.

[17] "I should rather see ideal science in this latter way: scientists with time to explore beyond what would normally be practical, would in the long run get to a best system. That would be enough for me. It is enough to say that a best systematization is *an* aim of science, even if it is not the only aim." Halpin (2003), p. 162.

[18] Halpin (2003), 151-2.

Halpin distinguishes among three main perspectives: what he calls the *standard perspective*, the *stipulative perspective*, and the *philosopher's perspective.* These are different perspectives on our actual world and its Humean mosaic, which result in different best systems of laws. Halpin invites us to think of possible, non-actual other worlds and what the best system of laws would be in these other possible worlds. The *standard perspective* tells us that the laws in other possible worlds would be none other than our own current laws in our actual world. The *stipulative perspective* tells us that the laws in other possible worlds are stipulated by taking, for example, an ideal approximation to our current world and its laws as the best system. The *philosopher's perspective* enjoins us to think of each possible world has having its own best system of laws, without taking our own actual world and projecting its laws into other worlds. Thus, the philosopher's perspective is said to be the more objective in providing the best system of laws for any possible world. Which perspective to adopt depends to a large degree on the interests of the observer. As Rachel Briggs has observed, if the observer is "interested chiefly in building models for the laws at her own world, she can adopt the standard perspective, under which all counterfactual worlds are stipulated to have the laws of her world…On the other hand, if the observer is interested chiefly in explaining how the categorical facts determine the laws, she can adopt the *philosopher's perspective*, under which each world is assigned the laws that it would have, were it actual".[19]

Hence, PBSA improves upon Lewis' BSA on the score of subjectivity. For to be a law is not a matter of being regarded as such, according to subjective or psychological standards. The subjectivity affecting BSA can instead be understood in perspectival terms. It is a product of the observer's different interests (and different vantage points) when thinking about the best way of systematizing the Humean mosaic: either from some sort of God's eye view (the philosopher's perspective), or from our own current standpoint (the standard and stipulative perspective).

This feature of PBSA is important for realism about laws. For PBSA agrees that laws "are 'there' to be discovered, are independent of any actual theory, though their reality is relative to perspective".[20] In a truly empiricist spirit, PBSA takes nature to be teeming with lawful regularities. These regularities exist and would have existed even if we had not existed. Indeed, "worlds without thinking beings have laws. These laws might be projected from our own world (the Standard or Stipulative perspectives) or be the best system of that world (on the Philosopher's Perspective)" (ibid., p. 164). However, PBSA departs from Lewis' ontology of natural properties and natural predicates, precisely because it rejects Lewis' assumption about

[19] R. Briggs (2009), p. 87.
[20] Halpin (2003), p. 163.

one single Best System. By going perspectival, more than one best system is allowed. PBSA defends then a peculiar kind of realism about laws: it is Humean in its fundamental ontology of sparse natural properties; but it rejects Humean supervenience because laws in other worlds *w** do not necessarily supervene on the Humean mosaic of actual natural properties at our own world *w*. More to the point, what laws there are at any other possible world *w** is indeterminate until a suitable perspective is specified.

Halpin maintains that these perspective-dependent projections of our own laws onto other possible worlds *w** improve on Lewis' BSA also on the score of nomic necessity. Laws under Lewis' BSA are just factual occurrences of regular events. No necessity is there to be found. But PBSA promises to deliver on nomic necessity: the nomic necessity of the laws is said to be a consequence of perspective-dependent projections.[21] As I understand it, nomic necessity under PBSA would then be nothing but the resilience of our own laws projected (under either the Standard or Stipulative perspective) onto other possible worlds *w**. These perspective-dependent projections fulfill some practical requirements. When thinking about counterfactual worlds *w**, it is just easier and more convenient for us to project antecedent conditions that are akin to the ones in our own current world *w*, and to expect the consequents to follow according to lawful patterns holding here at world *w*. Nomic necessity, in Halpin's account, is downstream of this practicality. It is not the product of any metaphysics of dispositions, or of necessitation relations between categorical properties. In a truly Humean fashion, nomic necessity is nothing but the necessity with which past experience brings along with it the *expectation* that the same lawful patterns occur in other possible worlds (via perspective-dependent projections).

In the next Section, I lay out a new version of perspectival Best System Account, which I am going to indicate as *npBSA* (to distinguish it from Halpin's PBSA). I highlight similarities and points of departure both with RBSA and PBSA, and explain how *npBSA* has the potential to address the three problems of subjectivity, realism, and nomic necessity in a novel way.

3. A novel *perspectival* Best System Account of lawhoow (*npBSA*)

[21] "Laws are necessary in the sense that we tend to project them onto hypothetical situations. At the heart of nomic necessity, then, is the practicality of perspective dependence. (It would be impractical to use laws other than our own to project out possible sets of initial conditions – for example, it would not be particularly useful to project out initial conditions in accordance with principles under which gold is as hard as diamond). As I see it, then, the Humean can explain nomic necessity by reference to this practicality. It is worth stressing this result. It allows the proponent of the BPSA to make sense of modal character without compromising empiricism." Halpin (2003), p. 160.

What is to be said about the two friendly amendments to Lewis's Best System Account discussed in the previous Section? They both strive to improve on the standard BSA on various counts. And they are both appealing in zooming into scientific practice and bringing to the table Kuhnian considerations from the history of science. Yet, in my view, both fall short of delivering on the full potential of the lessons coming from the history of science and scientific practice. And for different reasons too.

RBSA falls prey of the same diagnosis made for Lewis' BSA at the end of Section 1. It puts the metaphysical cart in front of the epistemological horse. For Lewis' emphasis on sparse natural properties is here replaced by relativized kinds, with lawhood defined with respect to them. Thus, in the end it is the relativity of our scientific kinds across the history of science that dictates the need for a relativized BSA. Lawhood is once again at the mercy of ontological considerations. A different way of vindicating what is undoubtedly the important Kuhnian motivation behind RBSA places emphasis not on kinds (or predicates), but on the standards used to assess the best system at any historical time. In other words, a different way of thinking about the Kuhnian move behind RBSA is in terms of the *relativity* of the standards of simplicity, strength and balance across time and scientific communities (rather than kinds). Second, something has to be said about nomic necessity and how laws in BSA do not become subjective (the menace of the ratbag idealist, notwithstanding) even if the standards of simplicity, strength and balance might well change over time and across communities. A revised version of BSA has to make room for the standards to vary over time and yet deliver laws that are resilient to theory-change.

Halpin's perspectival account of BSA is a very welcome move in this direction. For it cashes out lawhood in terms of different perspectival standpoints and introduces nomic necessity as a consequence of the practicality of perspective-dependent projections of laws. Yet Halpin's account too does not give history of science its due, in my view. For "perspectives" are not understood as real scientific perspectives endorsed by real communities across the history of science. They are instead understood as idealized continuation of actual scientific culture. The problem, as I see it, with this quasi-Peircean take on "perspective" is that it rides roughshod over the historical contingencies affecting the Lewisian standards of simplicity, strength, and balance. Historical contingencies are the primary culprit for the contextual and situated nature of the standards employed at any time to define what counts as "the best system".

More to the point, the three perspectival standpoints (standard perspective, stipulative perspective, and the philosopher's perspective) take either our current perspective (or some God's eye view in the case of the philosopher's perspective) as the privileged standpoint for projecting laws onto other possible worlds. But our view *from here now* should not beg epistemic priority on other historical views *from there then.* Given that standards are contextual, a *bona fide* perspectival approach should deliver a fully dynamic view of how standards have evolved and changed *from there then* (say, at Lavoisier's time) *to here now* (say, contemporary physics on conservation of mass). In what follows, I take some preliminary steps towards cashing out a novel perspectival view on the Best System Account, which takes perspectives as real scientific perspectives of real historical communities across time. My account shares with both RBSA and PBSA the same rationale for amending Lewis' BSA (namely, attention to scientific practice and perspectival understanding of contextuality). Yet it gives novel answers to the old problems of subjectivity, realism, and nomic necessity. Let us start with three definitions, just to get clear on the main notions I am going to use henceforth.

Scientific perspective (*sp*): A scientific perspective *sp* is the actual—historically and intellectually situated—scientific practice of a real scientific community at a given historical time. Scientific practice should here be understood to include: (i) the body of *scientific knowledge claims* advanced by the scientific community at the time; (ii) the experimental, theoretical, and technological resources available to the scientific community at the time to *reliably* make those scientific knowledge claims; and (iii) second-order (methodological-epistemic) claims that can *justify* the scientific knowledge claims advanced. Metaphysical, philosophical, religious beliefs that might have been present at the time in the community do not count as part of a scientific perspective. For they cannot explain either how the community comes to *reliably* make, or *justify* those scientific knowledge claims.[22]

[22] I do not have the space to expand on this point but suffices to say that I am here endorsing a two-component view of knowledge claims. *Reliabilism* explains how the community comes to true knowledge claims via certain experimental, theoretical, and technological resources available at the time. P*erspectival coherentism* (to use Sosa's expression), in turn, justifies those knowledge claims as part of an epistemic perspective of the community at the time. The epistemic perspective includes not just first-order knowledge claims about the objects under investigation, but also second-order methodological claims that justify the reliability of the experimental, theoretical and technological resources used to make the first-order knowledge claims (see Massimi 2012 for more details on this point). The point of this two-component view (following up on Sosa 1991) is to exclude Kuhnian scenarios where, say, Kepler's neo-Platonism might be regarded as contributing (either to the truth or to the justification) of his knowledge claims about Copernicanism. Kepler's neo-Platonic beliefs, much as they were present and influential at the time, did not play a direct role in establishing either the *truth* or the *scientific justification* for knowledge claims about Copernicanism. Tycho Brahe's observational data, and Kepler's laws (and all the experimental, theoretical and technological resources to get to them) should instead be counted as part of the epistemic perspective of the community at the time. Thus, my understanding of scientific perspective is closer to Giere's (2006) than it is to Kuhn's scientific paradigm (which does include metaphysical and philosophical beliefs among others).

Simplicity, Strength, and Balance at sp (SSB_{sp}). Simplicity, strength, and balance are always contextual standards, typical of a given scientific perspective *sp* at a given historical time. Different scientific perspectives deploy slightly different sets of standards (SSB_{sp1}, SSB_{sp2}, SSB_{sp3},…— more on this point in the next definition). The perspectivalist of the kind here envisaged understands SSB_{sp} as *standards of performance adequacy*. They do not define either the truth or the justification for the scientific knowledge claims advanced within a scientific perspective. Instead they monitor the ongoing performance adequacy of the scientific knowledge claims at stake. Namely, these standards are used to monitor how well those scientific knowledge claims serve the epistemic needs of the original community who advanced them, and the needs of any subsequent scientific community that inherits them from the earlier scientific community.

Standards of performance adequacy in sp: Simplicity and strength are just two of the standards of performance adequacy employed by scientific communities to monitor how well scientific knowledge claims serve their epistemic needs. The list is much longer and open-ended (e.g. consistency, accuracy, predictive power, explanatory power, just to name a few).[23] Insofar as the epistemic needs of scientific communities tend to be similar across time and across scientific perspectives, these standards too tend to stay the same across time and across scientific perspectives. Simplicity was a value for Newton no less than for Lavoisier. As such, these standards are constitutive of scientific inquiry across historically and intellectually situated scientific

[23] The attentive reader will not have failed to note the Kuhnian flavor of this list, which is somehow reminiscent of what Kuhn called the "values" part of a disciplinary matrix (see Kuhn Postscript 1970, p. 184-5): "Usually they are more widely shared among different communities than either symbolic generalizations or models, and they do much to provide a sense of community to natural scientists as a whole. Though they function at all times, their particular importance emerges when the members of a particular community must identify crisis, or later choose between incompatible ways of practicing their discipline. Probably the most deeply held values concern predictions: they should be accurate; quantitative predictions are preferable to qualitative ones;…There are also…values to be used in judging whole theories: …they should be simple, self-consistent, and plausible, that is compatible with other theories currently deployed. (…) values may be shared by men who differ in their applications. ..judgments of simplicity, consistency, plausibility and so on often vary greatly from individual to individual….In short, though values are widely shared by scientists and though commitment to them is both deep and constitutive of science, the application of values is sometimes considerably affected by the features of individual personality and biography that differentiate the members of the group." In my view, it is this latter feature of Kuhn's characterization of values such as simplicity (i.e. their variation in application from individual to individual, their being dependent on individual personality and biography) that Lewis was at pain to avoid (and negatively branded as the lunacy of the ratbag idealist). So, to improve on Lewis' BSA without falling back into the lunacy he dreaded most, something has to be said about how these values are both constitutive of science, while also changing over time.

perspectives. This is important because these standards allow scientific communities to assess the ongoing performance of scientific knowledge claims across time. Scientific knowledge claims concerning specific laws of nature that continue to fare well on the scores of simplicity, strength and their balance over time are justifiably retained in subsequent scientific perspectives; they are discarded, otherwise.[24]Yet there is a sense in which these standards also vary (not among individuals, as Kuhn had it) but among scientific perspectives. Thus, while deeply constitutive of scientific inquiry and fairly stable across theory change, standards of performance adequacy are also subject to interpretive shifts across scientific perspectives. Our perspectival account of BSA ought to reflect this twofold feature.

With these definitions in place, we can now give a first stab at defining a novel perspectival Best System Account of lawhood as follows:

(*npBSA*) Given a scientific perspective *sp*, and given SSB_{sp} qua standards of performance adequacy, laws of nature are axioms or theorems of the *perspectival series* of best systems, which satisfy SSB_{sp1}, SSB_{sp2}, SSB_{sp3}, and so forth.

(*npBSA*) improves on Lewis' BSA on several counts. First, it avoids the implausible "view from nowhere" that affects Lewis' definition of best system, with all ensuing objections that have been leveled against it (most famously, van Fraassen's objection against Lewis' "eschatology of science"). There is not just a single Best System; a privileged philosopher's Best System à la Halpin (or what Ned Hall calls Lewis's LOPP). Instead, there are several BSA across the history of science, as many as there are clearly identifiable scientific perspectives reinterpreting the standards of simplicity, strength and their balance.

Second, (*npBSA*) takes on board the Lewisian vagueness about simplicity and strength and interprets it not as a matter of psychology, but as perspectival standards of performance adequacy endorsed by real scientific communities. The natural advantage of this move is that it undercuts the possible menace of the ratbag idealist dreaded by Lewis. Moreover, it eschews the

[24] In this sense, I agree with Kuhn that these values are important to assess eventual crises and to choose between incompatible ways of practicing a discipline. They provide a canon for assessing how well scientific knowledge claims continue to perform over time, or whether they fail by their own lights.

problem of subjectivity that haunts Lewis' BSA. For simplicity, strength and balance are not to be understood as figments of one's own psychological make-up. Nor are they by-products of mob psychology either. Given what a scientific perspective is (in terms of making *reliable* scientific knowledge claims and being able to *justify* them), and given the role of standards of performance adequacy (in terms of assessing the ongoing performance of scientific knowledge claims vis-à-vis the epistemic needs of a scientific community), no dreaded idealist lunacy looms on the horizon. Third, *npBSA* stresses (even more than Lewis ever did) the contingency of lawhood on the perspectival series of best systems. And contingency is here understood in terms of contextual or perspective-sensitive standards for the best system at any one time (SSB_{sp1}, SSB_{sp2}., SSB_{sp3},…).

On the *npBSA* account of lawhood, Newton's law of gravity is a theorem in the best system at Newton's time (defined with respect to SSB_{sp1}, say, with simplicity understood as "true and sufficient causes" for phenomena). And it continues to be a theorem in our best system now (say, SSB_{sp2}, with simplicity reinterpreted along the lines of geometrized Newtonian gravitation, for example). Mass conservation was an axiom in the best system at Lavoisier's time (where strength was a large-meshed net that allowed for caloric to feature among non-nomic facts). And it continues to be an axiom in our best system now, despite our standard of simplicity and strength having been drastically recalibrated to exclude the deduction of caloric-related phenomena. Momentum conservation was a law in the Cartesian best system, and it continues to be a law in our current best system, where strength has been redefined to encompass not just elastic collisions in classical mechanics, but also deep inelastic scattering, jet fragmentation, and hadronization among others in high-energy physics.

More importantly, *npBSA* has also the potential of addressing the problems of realism and nomic necessity. Laws of nature are real because there are genuine regularities in nature, whose behavior can be discovered and expressed in mathematical language (be it differential equations or else) within a system of scientific knowledge claims that satisfies perspectival standards of performance adequacy such as simplicity, strength, and their balance. The perspectival nature of the best system at any given historical time does not affect the reality of the regularities captured by the laws. What Lavoisier observed about weight being conserved in combustion and calcination processes was real then as it is now. What Descartes observed about the collisions of rigid bodies was real then as it still is nowadays when we consider how quarks and gluons get knocked out of protons to form new hadrons. By making simplicity, strength, and balance perspectival standards of performance adequacy, the reality of occurrent regularities remains unscathed (no matter in which lawful dress we may deck them out across the history of science).

This is an important feature of the present proposal that feeds into a larger project (namely, cashing out *perspectival realism* in science), whose discussion will have to wait for another occasion. For I want to conclude this brief exposition of *npBA* with a discussion of what I consider the main advantage of the position: i.e. the way it retrieves nomic necessity.

As discussed above, the lack of nomic necessity has been a repeated source of complaint against Lewis' BSA. Halpin's BPSA set out to improve on Lewis' account by thinking of nomic necessity in terms of perspective-dependence projections of our own laws into other possible worlds. Yet, in my view, it remains unclear how projecting our laws onto other possible worlds is ever going to bestow modality to those laws. Unless the projectivist account has a pretty convincing story to tell about what makes our own laws modally robust in the first instance, nomic necessity does not accrue for free via perspective-dependence projections. Thus, while I share Halpin's quasi-Humean intuition that the practicality of perspective-dependence is at the heart of nomic necessity, I part my way from Halpin's understanding of it.

For I read "practicality of perspective-dependence" in terms of resilience across perspectival changes in simplicity, strength, and balance (SSB_{sp}) in different best systems. In other words, it is the resilience of our laws (such as conservation of mass, momentum conservation, or Newton's law of gravity) despite the contextuality of our standards of simplicity and strength that is testimony to the nomic necessity of these laws. Pragmatic considerations about how these laws have served our predecessors—and continue to serve us so well today—provide good reasons for taking the underlying empirical regularities as nomologically necessary (perspectival simplicity, strength, and balance notwithstanding). In other words, no matter how the standards of simplicity and strength (individually and/or jointly) change across scientific perspectives, it is ultimately the (always renegotiable) *balance* between these two revisable standards that allows us to trace nomic continuity across historical periods and scientific perspectives.

Humeans are usually faced with a dilemma. Either (1) a causal-glue-free mosaic of natural properties, which can only make factual (but not modal) claims about what has been, is, and will be the case (e.g. "there has not been, is not, and will not be a perpetual motion machine", as opposed to "there *could not* be a perpetual motion machine"). Or, (2) capitulate that laws do not supervene on matters of fact, and worlds identical as to matters of fact can yet be different in their laws depending on whether property F-ness necessitates G-ness in world w_1 but not in w_1, as Necessitarians would argue.[25]

[25] For this anti-Humean argument, see Carroll (1990).

In reply, I suggested that Humeans can avail themselves of an alternative way of thinking about nomic necessity, whereby nomic necessity is neither an emanative effect of dispositional essentialism; nor a metaphysical liability, as with Armstrong's Necessitarian account of laws. For nomic necessity might well be nothing over and above the resilience of lawful scientific knowledge claims across different scientific perspectives. There is no need for either postulating unexplicable necessitarion relations between universal properties; or a causal glue between, say, mass **m** and velocity v (when it comes to the law of momentum conservation). Laws of nature are nomologically necessary as long as they feature as axioms or theorems in a perspectival series of best systems across different scientific communities and times. It is the (always renegotiable) balance between the revisable perspectival standards of simplicity and strength from sp_1 to sp_2 and so forth, which ultimately secures the nomological necessity of our fundamental laws across scientific perspectives. Mass conservation or momentum conservation *are necessary* because they resiliently feature in our perspectival series of Best Systems, no matter how our epistemic needs might have changed across centuries, and our perspectival standards with them. Of course, this nomic necessity is contingent on us (as Lewis would have it), and on our historical, perspectival Best Systems (as I would add). Critics are going to remain unimpressed by this move. For nomic necessity is usually associated with either some metaphysical machinery designed to deliver on it; or with some invariance under counterfactual antecedents (e.g. "if Lavoisier had not existed, it would still be a law that mass is conserved"; "if Descartes' physics had never been conceived, it would still be a law that momentum is conserved"). In reply, I'd say that *given the perspectival standards* there are not two worlds with the same Humean mosaic but different laws. But *without the perspectival standards* (and in the absence of plausible LOPP candidates!) there might well be two worlds with the same Humean mosaic and different laws. Weak as this might sound, it strikes me as a historically more viable option than nomic necessity being contingent on which categorical property necessitates which other in an Armstrongian world.

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